Agroterrorism is a real threat that has become a significant concern in recent years. Agents against animals and crops have been part of nearly every nation sponsored offensive biowarfare program. We must take measures to address this threat and call attention to the seriousness of an attack on agriculture. Increasing awareness and preparedness about the threat of agroterrorism and the subsequent impact it could have is vital to preventing an attack and in mitigating the consequences should one occur. Sections of this presentation were taken from “Davis RG. Agroterrorism: Need for awareness. In: Scanes C, ed. Perspectives in world food and agriculture: 2003. Ames, IA: ISU Press. In press., 2003.”

An attack on agriculture took place in late 1996 when police received an anonymous call from a worker at a rendering plant in Wisconsin. The caller said liquid fat from the plant had been contaminated. It was determined that the contaminate was chlordane, an organochlorine pesticide that is environmentally stable, accumulates in the fat of animals, and is considered a food adulterant at very low levels (0.3 ppm in animal fat). This fat found its way to feed manufacturers and eventually on to nearly 4,000 farms in Wisconsin, Minnesota, Michigan and Illinois. Within two days all major customers were notified and the feed was replaced. Luckily, milk samples taken from some of the dairy herds that had eaten the affected feed were negative or contained levels well below those that pose a health hazard to humans. Total costs for disposing of the contaminated feed (4,000 tons) and fat (500,000 pounds) was almost $4 million; however, as numerous state and federal agencies became involved in dealing with this issue, the final price tag was likely much higher.

During this presentation we will define the goals of agroterrorism, convey the importance of agriculture to our nation, realize the impact agroterrorism could have on our nation, learn which agencies are involved in mitigation and response, identify the agents of potential use against livestock and plants, and address any public health concerns.
Agroterrorism has never been officially defined; however, for our purposes it will be defined as the use of biological (to include toxins), chemical, or radiological agents against some component of agriculture in such a way as to adversely impact the agriculture industry or any component thereof, the economy, or the consuming public.

There are several components to terrorism. Bioterrorism, often defined as the use of biological agents that target humans, plants or animals is what we think of the September 11th attacks and anthrax letters that were used in 2001. As described in the previous slide, agroterrorism, for our purposes, will be defined as the use of biological (to include toxins), chemical, or radiological agents targeting agriculture or its components and its adverse impact on livestock, the food supply, crops, industry, workers, the consuming public, and our economy. And finally, there are other terrorism components such as conventional, radiological, nuclear, chemical and cyber that are typically directed at the human population.

Fear is a component with agroterrorism, but the primary outcome is severe economic losses and a decreasing export market. If we cannot export, we lose money, farms, jobs, and international stature. Export revenues accounted for 20-30% of farm revenues over the last 30 years and are expected to continue in this fashion in the future. In 2000, the U.S. exported meat to the tune of $3.1 billion for beef and veal, $1.3 billion for pork, and $1.8 billion for poultry. All told, we exported nearly $51 billion in agricultural commodities in the year 2000, and $39.3 billion came from non-animal products.

The attack on plants and animals evokes less emotion than an attack on humans would, resulting in there being less likelihood of a retaliation. An attack on a crop or herd may go undetected for many days, or even weeks, allowing the perpetrator ample time to escape. The use of agroterrorism pathogens also carries with it the ability of a nation or terrorist organization to deny involvement and point toward natural circumstances as the cause—“plausible deniability” is what some refer to this as. Also, the goals behind agricultural bioterrorism are different than those for humans. We tend to expect the targeting of people, not animals or plants.

Clues generated by the outbreak itself might point toward an intentional introduction. These clues might include: traceback of animals that yield a dead-end with no evidence of exposure to other infected animals or common feed; animals that have not passed through a common sale barn or farm; a history of other events that have happened at that farm/facility that might be tied to a particular employee; the occurrence of several, smaller outbreaks across the nation at one time; the manifestation of signs not typically seen with a particular disease that suggest an atypical route of exposure; overwhelming mortality; or unusual season of occurrence. These taken separately might not alert the investigator to agroterrorism, but the combination of two or three, plus other history or suspicions, might be all that is needed to make the connection.
There are many methods of delivery and points in the agriculture process that an agent could be introduced. Most likely, covert introductions will go unnoticed for a longer period than overt introduction. The simultaneous release of three to four highly contagious, foreign animal pathogens in several locations around the country at key points would be overwhelming. While the topic of agroterrorism is highly concerned with the intentional introduction of foreign agents, there is the possibility that international travelers might bring one or more of these microbial agents into the U.S. accidentally. At first onset, an intentional outbreak of a disease in animals or crops is hard to differentiate from a natural outbreak, which delays finding the true source. False claims and hoaxes can be introduced to diminish public confidence in food safety for particular commodities or products. A false report of one case of BSE occurring in the U.S. would send the beef industry into a tailspin for a brief time, losing perhaps tens of millions of dollars or more in overall costs. Foreign trading partners might hear of the rumor and implement a trade ban. The perpetrator relies upon the media to do the damage for him/her by spreading the rumors and presenting fiction as fact.

Next we will cover some of the historical aspects of biological warfare programs and agroterrorism.

It has been pointed out that the first use of biological weapons in the twentieth century was not against humans, but against animals. One of the first known offensive biological weapons programs was begun by Germany around the time of WWI. Their enthusiasm for biowarfare continued into the years of WWII, during which time they experimented with airborne foot-and-mouth disease virus. France, whose biological program began in 1921, had researched the use of rinderpest against cattle, and late blight (the cause of the Irish potato famine that killed one million in 1845-46) and the Colorado beetle. Germany also researched these two pathogens, but they also investigated leaf-infecting yellow and black wheat rusts, rapeseed beetle, and the corn beetle. According to what is known, the Germans were very close to using the Colorado beetle against British potato crops by June 1944, but it was too late in the season and the war ended before they could make use of it. Anti-agricultural biological weapons, overseen by the Ministry of Agriculture, were also developed by the Soviet Union in the late 1940s to early 1950s under the project name “Ecology”.

The U.S. began its offensive biological warfare research in the fall of 1941, looking into the potential of using biological agents for warfare being submitted in early 1942. With all the agents on typically associates with a biological program targeting humans included, the committee also suggested there should be serious consideration into the research of Newcastle disease virus, foot-and-mouth virus, hog cholera, rice blast, cereal stem rust, wheat scab, and late blight of potatoes. The U.S. produced and stockpiled 30,000 kilograms of *Puccinia graminis tritici* spores, which causes stem rust of wheat, between 1951 and 1969. Additionally, the U.S. chose *Piricularia oryzae* as its primary pathogen against rice and had roughly one ton stored up by 1966. Other crop targets of the U.S. program included soybeans, sugar beets, sweet potatoes, and cotton. Wheat in the Soviet Union and rice in Asia were identified as targets.
The end of the U.S. offensive biological program was announced on November 25, 1969 by then President Richard Nixon, and finalized on February 14, 1970 with the amendment of including toxins in the final ban. The 1972 Biological Weapons Convention (BWC) treaty was finally ratified by President Gerald Ford on January 22, 1975. The reason behind the U.S. eliminating their BW program was from a practical, military standpoint; there were other weapons that could be used where the results were virtually guaranteed. Biological weapons were generally unpredictable compared to conventional weapons: they required great skill, familiarity, good timing, and were essentially unproven; and they could be lethal if winds shifted. Stopping the program due to the extreme cost of continuing to operate and the aging of U.S. BW facilities made good sense. By banning biological and chemical weapons, that, in theory, left only nuclear weapons as the last remaining WMD.

This next section demonstrates how important agriculture is in our society and to our economy.

This 1997 map depicts the location of nearly 2 million farms that take care of 1 billion acres of farm land. It is a monumental task to protect all of our farms and food supplies and requires everyone’s efforts. Vigilance on the part of the farmer/producer is essential, and so too is early reporting.

U.S. agriculture has changed in the last century as this slide portrays. It is estimated that in 1900 roughly 39% of the U.S. population lived on farms, today that figure is less than 2%. Farms today are more specialized and much larger and consolidation is occurring on all levels. The U.S. has seen the demise of oat farming (45.5 million acres in 1921 to less than 3 million acres in 1998) and the rapid growth of soybeans (less than half a million acres in 1920s to nearly 60 million in the 1990s). Consolidation in agriculture has also taken place in related off-farm businesses. In the U.S. we slaughter an average of 130,000 head of cattle per week and this is now a business that is dominated by three large companies.
According to Edmondson, in 1999 the U.S. food and fiber system accounted for 16.4% GDP, and it added $1.5 trillion to the National GDP. The farm sector alone accounted for $69.8 billion. Foreign trade in agricultural products generated $51 billion in exports in 2000. In 1999 approximately 17.4% (24.3 million people) of the total U.S. workforce was involved in the food and fiber system in some manner. Agriculture is also heavily tied to other industries (good and services), such as equipment manufacturers, feed suppliers, transportation, food retailers, restaurants, hotels, and tourism, to name just a few. A healthy agriculture economy is vital to the U.S. economy as a whole. Any significant disturbance in this system has the potential to: create higher prices domestically and abroad, increase unemployment, reduce trade, and result in a concurrent negative impact on reliant industries.

From cattle to turkeys, livestock and poultry generate needed income for producers and the economy while supplying safe product to our tables. Listed are the economic importance of livestock and poultry in our nation and estimated numbers as of 2001. These are live animal values and do not consider the value of the products we harvest from these species. Interesting to note that in 2002, the U.S. was second only to China for egg production, and produced more eggs than the whole of the European Union combined.

The food of America is now produced by fewer farmers located in more geographically defined parts of the country: pigs in Iowa, North Carolina, and Illinois; beef cattle are fairly widespread but Texas, Kansas, and Nebraska are the country’s biggest producers; dairy operations are widespread too, but we do see this industry heavily tied to the states of California, Wisconsin, Pennsylvania, and Minnesota; broiler chickens in Georgia, Alabama, and Arkansas; egg layers in Iowa and Ohio (on the next slide); corn in Iowa and Illinois; soybeans in Iowa and Illinois; and wheat in Kansas and North Dakota. This consolidation means that use of animal or crop agents could be used in a relatively focused region of the U.S. but have widespread national repercussions.

Decreased genetic diversity is not limited to plants that have been genetically enhanced to resist pests and disease, but includes animals as well. Animals that are genetically similar offer the producer predictable operating costs and end results, and they offer the consumer a predictable quality slice of meat or a consistent dozen of eggs. However, these finely tuned plants and animals are also more at risk from a designer pathogen engineered to exploit this lack of diversity.

USDA data. Looking at crop production: Corn for grain accounts for the greatest value based on sales; soybeans are second, followed by wheat. The large majority of corn goes to the feeding of livestock here in the U.S. The leading U.S. export crop for 2000 was corn ($4.6 billion), followed by wheat ($3.6 billion). Looking at single crops, corn for grain accounts for the greatest value. There is $1 billion in seed exports.
USDA data. Looking at commodity exports: Soybeans accounted for the highest exports with corn being second, followed by wheat. The large majority of corn goes to the feeding of livestock here in the U.S. The largest animal product exported is beef/veal followed by poultry meat and dairy products. Total agriculture exports in 2001 amounted to $52.7 billion dollars.

Now that we have explored the importance and economic value of agriculture, we will examine what type of impact an agroterrorism attack could have on American soil.

Impact

- Potential for mass disruption
  - Weaken workforce
  - Destabilize government
- Shocking public images
- Loss of freedoms
- Loss of consumer confidence
- Higher prices?
- Food shortages?

Terrorism targeting agriculture has the potential to cause mass disruption, to weaken a workforce and to destabilize government. The reality is that terrorism does not need to infect all of our soybean crops or all of our beef cattle to create economic hardship, loss of consumer confidence, or panic. The impact and consequences from a foreign animal disease such as FMD in the U.S. could be severe. Harsh restrictions on movement would be enacted. We would see road closures, quarantined farms, and animal movement would stop. Access to campsites, state parks, wilderness areas, lakes, city parks, and zoos may be denied. The public could be shocked by some of the images the outbreak produces and lose confidence in our food products as consumers. Depending on the extent of the outbreak, meat prices could skyrocket in some areas and drop in others. It is unlikely that an agroterrorist attack would create mass food shortages; but movement restrictions could complicate availability temporarily.

Monetary Impact

- Quickly felt by state/federal economy
- Loss in trade
- Other industries damaged
  - Restaurants, suppliers, tourism, zoos, hunting, etc.
- Direct costs
  - Diagnostics, surveillance, depopulation, cleaning, disinfection, indemnity, overtime

The impact could be felt, in the case of a foreign animal disease discovery, in as quickly as 24 hrs. Exportation and importation of livestock could be halted. Tourism would drop, just as was seen in the U.K. There are direct and indirect ties to agriculture by allied and reliant industries, and a significant event would have a domino effect. Restaurants, grocery retailers, food processors and distributors would be affected, as would transporters. Seed companies may actually give away seed to help stimulate the farming sector and to stay in business. The direct costs of eradication and control involve disease surveillance, diagnostic testing, traceback on animal movement, implementing and maintaining quarantines, depopulation costs, indemnity paid to the farmer, overtime for law enforcement, hiring additional veterinarians, overtime for USDA and other federal or state employees … the list goes on and so do the costs. Losses due to a foreign animal disease may take years to fully realize.
Today, it is estimated that the U.S. currently loses $33 billion a year to plant diseases, $21 billion (65%) of which is attributed to nonindigenous plant pathogens. We also lose approximately $7 billion in forest products due to pathogens of forest plants, $2.1 billion of this is due to nonindigenous pathogens.

Next we will discuss the agencies in the United States that are protecting our borders, farms, and food supply seven days a week, 24 hours a day.

With the possibility of the intentional release of biological agents against our livestock and crops, the US must be able to respond in a decisive manner. The lead federal agency in safeguarding American livestock and poultry health, and in responding to a foreign animal, emerging or reemerging disease, is the USDA-APHIS, Veterinary Services division (VS). The Emergency Programs (EP) division, founded in 1972, prepares and trains for response to outbreaks of foreign or newly emerging animal diseases. EP provides training to many veterinarians and support personnel whose work requires knowledge of foreign animal diseases. In the event of a foreign animal disease outbreak, these trained professionals would be called upon to help in diagnosis, control, monitoring, and eradication. The lead federal agency for plants is the USDA-APHIS, Plant Protection and Quarantine (PPQ) division.

Four USDA-APHIS laboratories comprise the National Veterinary Services Laboratory (NVSL) and provide services for the diagnosis of domestic or foreign animal diseases, import/export testing of animals, training, and testing for eradication or control programs. All NVSL laboratories are located in Ames, Iowa, with the exception of the Foreign Animal Disease Diagnostic Laboratory (FADDL) at Plum Island, New York, where foreign animal diseases are studied and veterinarians are trained to become foreign animal disease diagnosticians. There are roughly 400 trained foreign animal disease diagnosticians—private, state, federal, and military veterinarians—spread out across the nation that could be called upon in the event such a need arose. All suspected foreign animal disease (FAD) outbreaks must be investigated within 24 hours of notification.

The Department of Homeland Security (DHS), through USDA-APHIS, has the difficult job of protecting our borders and keeping foreign animal and plant pests out of our country. About 3,000 USDA-APHIS inspectors search baggage at airports and cargo at major ports of entry to ensure compliance with animal and plant import restrictions. In the event someone attempts to smuggle in banned items, the Beagle Brigade, a group of highly trained beagles trained to sniff out produce and meat, will alert officials. These 1,800 inspectors are stationed at over 100 ports and carry out roughly 2 million interceptions of illegal agricultural products each year. In the U.S. there are approximately 130 dog teams at 21 airports.
The Bureau of Immigration and Customs Enforcement (ICE) (formerly the U.S. Customs and Immigration) under the direction of the Department of Homeland Security, also helps to protect U.S. agriculture by conducting inspections of persons and luggage and by questioning travelers about their exposures while in another country. They also played a key role in inspecting over 41,000 U.S. maritime trading vessels in 1999. There was a 48% increase in trade entries from 1996-2001 which amplifies the chances of an accidental or intentional introduction of a disease agent. In FY2001 Customs processed 472 million persons entering U.S., and 5.7 million sea containers. Approximately 90% of the world’s cargo moves by sea containers. Lastly, in 2002, the U.S. imported 1.5 million cattle, 5.8 million pigs. There are many porous borders surrounding our country, so increased awareness and mitigation becomes more essential each day.

Additional safeguards against the introduction of unwanted pests are import quarantine stations run by USDA. Livestock and poultry being imported into the U.S. must be accompanied by an official health certificate and must undergo quarantine at one of four facilities: Newburgh, NY; Miami, FL; Los Angeles, CA; Honolulu, HI. Exceptions are those animals coming from Mexico and Canada, which are inspected at the ports of entry. The same requirements are set for imports of deer, elk, llamas, and other cervids and camelds. Special rules apply for zoo animals and ostriches and emus. Personally owned pet birds must go through one of six USDA-operated bird quarantine facilities: New York, NY; Miami, FL; San Ysidro, CA; Hidalgo, TX; Los Angeles, CA; Honolulu, HI. Those birds coming from Canada may enter without quarantine due to similar health standards there. Importation of plants or plant products must be accompanied by a phytosanitary certificate issued by the exporting country. There are 14 APHIS maintained import stations for commercial importation of plants/plant materials: Miami and Orlando, FL; San Juan, PR; JFK International Airport, Jamaica, NY; Hoboken, NJ; Houston, El Paso, and Los Indios (Brownsville), TX; Nogales, AZ; San Diego, Los Angeles, and San Francisco, CA; Seattle, WA; Honolulu, HI. Importation of dogs, cats, turtles, and monkeys is overseen by the CDC’s Division of Global Migration and Quarantine.

It is very likely that an agroterrorism attack against animals or crops will not be conducted openly or result in immediate awareness. Therefore, in an incident directed against animals the local veterinarian is likely to be the first responder when called to the farm to determine the cause of illness or death. It is important that veterinarians understand what to do and who to call in the event they suspect a foreign animal disease or an outbreak with suspicious circumstances. In addition to local veterinarians, USDA officials will also take part in response to an animal or plant outbreak if it is a significant threat. Other resources utilized can be universities and local, state, and federal human health agencies if the agent is chemical or zoonotic in nature. The services of local law enforcement as well as county or state emergency management divisions may be recruited, depending on the severity.

You will recall the chlordane contamination of animal feed in Wisconsin in 1996 that was discussed at the beginning of this presentation. Many different agencies responded to the incident as listed on this slide. Agroterrorism events can be far reaching involving large numbers of people and agencies.
Any species of economic importance can be a target for an agroterrorism event. High concentration of animals (feedlots, swine confinement units, poultry houses) could aid in the distribution of an agent. Auction markets mix animals which are then loaded and transported, sometimes over 1,000 miles where they are mixed with other animals. Since almost all severe, highly contagious diseases of livestock have been eradicated from the U.S, and the use of any vaccine for them is either nonexistent or rarely employed, livestock have limited immunity to foreign animal diseases (FADs). Another concern is our centralized feed supply. As feed can be an ideal vehicle in which to distribute an agent or compound, one feed manufacturer can supply hundreds or thousands of farms, unknowingly distributing an infectious disease agent throughout the country.

Should an agroterrorism agent be introduced, the U.S. is currently very inefficient in our ability to trace animal movement, making us vulnerable to economic devastation. A national animal identification plan has been discussed and may soon be implemented. We are a global society and our international trade and travel has greatly expanded in the last quarter century. With the widespread distribution of infectious disease agents in other countries, we are very vulnerable to the accidental or intentional introduction of these pathogens. Our mobile society leaves our borders open for trade, making us vulnerable to agents or contaminated equipment being smuggled in if inspections are not thorough. Another concern is the lack of biosecurity for our animals and plants, which will be further discussed in the next slide. Finally, there is also a great need to improve foreign animal disease (FAD) awareness and education among veterinarians and producers. We all must be able to recognize the signs and know how to report them in order to decrease our vulnerability to disease spread.

Biosecurity entails the efforts and measures employed in keeping out unwanted microbial agents and in minimizing the spread and risk of these disease agents to livestock, crops, and food supply. Biosecurity can be applied to a farm, a veterinary clinic, a laboratory, a county, a state, and a country. One key component and concern in agricultural biosecurity is the movement of animals, plants, people, and food. Biosecurity entails limiting access of visitors and wildlife, making visitors wear clean rubber/plastic boots and leaving them on the premises, disinfecting boots and supplies brought onto farm, wearing clean coveralls and removing them before leaving the farm, and keeping workers or visitors free from contact with livestock outside of the farm for a given length of time (e.g. 1-2 days) before returning. Biosecurity also means restricting the movement of vehicles such as feed, rendering, and milk trucks, their personnel, as well as personal vehicles, to defined areas on the premises so as to limit spread. Quarantining new animals is very important to high quality biosecurity.
Animal Movement

- Mixing of animals at auction markets
  - More than 5 million cattle pass through every year
- Transported via trucks
  - Dissemination of pathogens to other animals or fomites
- 1950-60- U.S. military secret testing

It is said that a pound of meat travels almost 1,000 miles on the hoof before finally finding its way to your dinner plate. Over 5 million cattle pass through auction markets annually, presenting many opportunities for a terrorism attack. Auction markets allow for mixing of animals from around the state or neighboring states, presenting the opportunity for the exchange of infectious diseases such as FMD or hog cholera, and exposing others in a crowded setting. Once sold, animals are loaded onto trucks which can serve as reservoirs for further dissemination of pathogens to other animals or fomites. Loaded trucks that are stopped and parked for any reason, may serve to infect animals in nearby trucks, or curious domestic animals or wildlife that wander closeby.

Wilson, et al. point out that the U.S. military carried out several test runs at sale barns back in the 1950s and 60s using water as a biological simulant and using small hand-held spray cans as their means of dispersal. These men carried out their “attacks” at sale barns without ever being discovered.

Potential Agents

Livestock and Plant Pathogens

As you have learned throughout this presentation, agriculture in the U.S. is driven by our ability to export. Changes in the disease status of one or more food animals will compromise our ability to export with devastating results. Livestock, poultry, and wildlife can be targets of an agroterrorism event and the impact will depend on the agent used, dissemination of agent and infected animals, rapidity of detection and response to control, trade restrictions enacted, and other factors. This next section will address some of the USDA high consequence livestock pathogens, as well as plant pathogens, that could be used in an agroterrorism attack.

USDA High Consequence Livestock Pathogens and Toxins

The USDA has identified some pathogens as being of high consequence and concern to livestock. This slide depicts the full list of diseases, and there is a handout available for audiences if you choose to use it. The Center for Food Security and Public Health has designed PowerPoint presentations on many of these diseases that you will find on the Bioterrorism CD-ROM and Agroterrorism CD-ROM.

Public Health Implications

- Several zoonotic diseases
  - Many diseases listed on the previous slide have human health consequences
- Mechanical (negligible threat)
  - Newcastle disease, swine vesicular disease
- Biological
  - Avian influenza, FMD

Several of the diseases listed on the previous slide have zoonotic potential. The human health consequences vary depending on the specific agent. For more information, please refer to the disease specific PowerPoints located on the Bioterrorism and Agroterrorism CD ROMs, or the wall chart. A 1998 USDA assessment entitled “The Potential for International Travelers to Transmit Foreign Animal Diseases to U.S. Livestock or Poultry” concluded that while it is possible for humans to transmit some of these diseases to animals, the risk, after taking into account various factors and circumstances, is negligible. High on their negligible list for mechanical transmission by humans to animals was Newcastle disease and swine vesicular disease. Only two diseases, avian influenza and foot-and-mouth disease (FMD), had any potential for biological transmission, but was considered very low.
An example of an agroterrorism agent that would have severe repercussions is foot and mouth disease (FMD) virus. FMD has not occurred in the U.S. since 1929 and would have great impact on our livestock sector if it did. This picornavirus is probably the most important infection in livestock in the world today. FMD is a highly contagious vesicular disease of cloven-hoofed animals that causes fever and the formation of vesicles in the mouth, on the tongue, muzzle, feet, teats, and vulva. Production losses can be great and death usually only occurs in the young. Sheep and goats often have very mild signs and cases may be missed if not examined closely. FMD can be transmitted by saliva, respiratory aerosol, direct contact, and vehicles (contaminated feed, coveralls, shoes, instruments, etc). It has also been shown that humans can harbor FMD virus in their respiratory tracts for up to two days, posing a theoretical risk for transmitting this agent to uninfected animals. The photo depicts ruptured vesicles on this pig’s leg and coronary band due to FMD. Any case of FMD discovered in the U.S. would need to be reported to the World Organisation for Animal Health (formerly the Office International des Épizooties (OIE) created in 1924) within 24 hours.

The detection of FMD, and other high consequence livestock pathogens, needs to be reported to the World Organisation for Animal Health (formally the OIE) within 24 hours. The OIE immediately informs all other countries at risk, i.e. those countries receiving our exports. Our borders could, and would, be shut down, and preventative action would be taken by all countries at risk. As is the case with BSE in Canada, once an infected cow was discovered, all live cattle exports ceased. Borders will not reopen until the country’s authorities deem it is safe. In the case of FMD, trade could not resume until 3-months after the slaughter of the last positive animal, given ongoing surveillance through serological testing has occurred throughout the disease monitoring process.

It is important to understand that FMD has and is currently occurring in many countries around the world. This map is taken from the World Organization for Animal Health (formally known as the OIE- Office of International Epizootics) website as of March 25, 2001, and while it is a little dated, gives an accurate assessment of the worldwide distribution of this disease.

Foot and Mouth disease virus (FMD) only infects cloven-hoofed animals: cattle, pigs, sheep, goats, buffalo, and various wildlife such as deer and elk. FMD could affect approximately 60 species of wildlife and zoo animals and could have an enormous impact on our food animal production. Listed are the animals at risk in the U.S. according to 2001 data. There is also a risk of it spilling over into wildlife and creating a permanent enzootic presence. It is important to note that FMD rarely affects humans. The fear of the economic impact and its affect on trade is the biggest scare associated with FMD. Countries around the world would refuse our exports of beef, pork, mutton, cattle, pigs, sheep, and dairy products. This means that the $3.1 billion in beef exports and the $1.3 billion in pork exports each year would vanish unless we control this disease very quickly. There have been many estimates as to the impact of a FMD outbreak in the U.S. Paarlberg, et al., in their recent analysis of a FMD outbreak in the U.S., estimated that $14 billion would be lost in farm income. This cow is salivating due to the painful vesicular lesions in her mouth making it difficult to swallow.
Estimates of the FMD impact on the U.K. put overall economic losses over £10 billion due to the total economic strain placed on the agriculture and food industry (£3.1 billion), compensation to farmers (£1.1 billion), tourism (£4.5 to £5.3 billion by 2005) and sports (£750 million). Indeed, while it is known that 6 million animals were slaughtered in the U.K. to control this disease, resulting in them reaching FMD free status in less than one year, the true costs will likely never be known. The public witnessed something few had ever seen. Mass slaughter was called into question, as were animal welfare and animal rights. Those involved found themselves having to justify nearly everything they did, but their actions were viewed by some as barbaric and unnecessary. Pollution from pyres of burning carcasses was intense in some areas and also impacted public health.

If a foreign animal disease became enzootic within wildlife in the U.S. there would be serious repercussions. Establishing an enzootic foci of at least one foreign animal disease would ensure that resultant trade disruption would be almost permanent. The incursion of rinderpest, heartwater, or FMD might be devastating to our wildlife or zoo species, and has the potential to adversely affect endangered species. In April 1985, an outbreak of FMD among mountain gazelles (Gazella gazella) in a nature reserve in Israel resulted in the deaths of approximately 1500 animals and had a 50% case-fatality rate. The virus also spread from the gazelles to unvaccinated livestock on neighboring farms resulting in cases in cattle, sheep, and goats. Spread beyond these farms was prevented due to the prior use of the vaccine in livestock. Control in zoo or endangered species would not be a simple matter of slaughtering, as could be used in our domestic livestock. Total expenditures for hunting, fishing, wildlife watching, and camping activities in the U.S. in 1996 amounted to $100 billion. A good portion of all of this could be lost, at least temporarily, by the incursion of high consequence livestock pathogens.

Newcastle disease affects poultry and is caused by a Paramyxovirus. There are nine avian paramyxovirus serotypes and Newcastle disease virus is designated as APMV-1. Newcastle disease virus strains are grouped into four different pathotypes based on their clinical signs and increasing virulence. These include: asymptomatic enteric, which is generally subclinical; lentogenic, which has mild or subclinical respiratory signs; mesogenic, which has respiratory and occasional neurologic signs; and velogenic, which is the most virulent pathotype with high mortality rates. Velogenic Newcastle Disease (vND) is endemic in many parts of the world including countries in Asia, the Middle East, Africa, and Central and South America. The United States and Canada have seen high mortality in wild cormorants caused by vND. Clinical signs in chicken flocks, include an initial drop in egg production followed by numerous deaths within 24-48 hours continuing for 7-10 days. Birds that survive may have permanent neurological damage including paralysis, and reproductive damage causing decreased egg production. The photo depicts a chicken with respiratory signs and increased salivation due to vND.

The first case of vND occurred in 1950 in partridges and pheasants imported from Hong Kong. In March of 1972 a national animal health emergency was declared and a major eradication campaign began. During the 2 year effort, 1,321 infected and exposed flocks were located and almost 12 million birds destroyed. The operation cost taxpayers approximately $56 million. It wasn’t until July 1974 that the U.S. had succeeded in eradicating vND. Outbreaks of vND have occurred since in the U.S. due to illegal importation of exotic birds and poultry. Humans can acquire eye infections by direct contact that consists of unilateral or bilateral reddening, excessive tearing, edema of the eyelids, conjunctivitis and subconjunctival hemorrhage. Infections are usually transient, the cornea is not affected, and human-to-human spread has not been reported.
Newcastle Disease

- 2002-2003: California outbreak
  - 2,662 premises depopulated
  - 4 million birds destroyed
  - $160 million impact
- Developing countries
  - Effects quality and quantity of dietary protein
  - Significant effect on human health

In October 2002, vND was confirmed in the State of California. Cases occurred in Nevada, Arizona, Texas and New Mexico. As of July 7, 2003, with the epidemic in the final phase of eradication, almost 4 million birds on 2,662 premises had been depopulated. Eradication efforts have cost taxpayers $160 million to date (July 2003). In developing countries with endemic vND this is an important limiting factor in development of commercial poultry and the establishment of trade links. Many developing countries rely on village chickens to supply a significant portion of dietary protein in the form of eggs and meat, especially for women and children. Continued losses from vND affect the quantity and quality of the food of people on marginal diets. The economic impact of vND is not only measured in direct commercial losses, but in some countries in the effect on human health.

Crops and Plants

One of the earliest recorded attempts of bioterrorism against crops took place during the civil war when the Union was accused of having introduced the harlequin bug, *Murgantia histrionica*, into the southern United States in hopes of destroying Confederate crops. In other historical anti-crop events, the U.S. was accused of dropping the Colorado potato beetle (*Leptinotarsa decemlineata*) on Germany during WWII, and again on East Germany in 1950. The U.S. even considered, briefly, destroying Cuba’s sugarcane crop with Fiji disease, a pathogen transmitted by leafhoppers. Photos on this slide include cotton, bread, and soybeans.

Plant Targets

- Food crops
  - Wheat: #1 grain export in 2002
  - Corn: #2 grain export in 2002
  - Soybean: U.S. produced ~46% of world’s crops in 1999-2000
- Fiber
  - Cotton
- Timber
  - Northwest U.S.

Crops influence our everyday lives, from what we eat, to our export markets, to what we wear and to the homes we live in. Wheat was the number one grain export and corn was number two in 2002. Agroterrorism need not focus on just animals or food crops. The US grows nearly half of the world's soybean crops in 1999-2000. Other targets include the cotton and timber industries.

Economically Damaging Plant Pathogens in U.S.

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Region</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus Canker</td>
<td>Florida</td>
<td>Erad program</td>
</tr>
<tr>
<td>Tomato Yellow Leaf Curl</td>
<td>Southern U.S.</td>
<td>Highly virulent</td>
</tr>
<tr>
<td>Plum Pox Virus</td>
<td>Pennsylvania</td>
<td>Erad program</td>
</tr>
<tr>
<td>Wheat rust</td>
<td>Nationwide</td>
<td>Varieties resistant</td>
</tr>
<tr>
<td>Sudden Oak Death</td>
<td>Northern CA</td>
<td>Highly destructive</td>
</tr>
<tr>
<td>Rice Blast</td>
<td>Southern U.S.</td>
<td>Easily spread</td>
</tr>
</tbody>
</table>

There are many economically damaging plant pathogens found in the United States and there is no way to address them all in the time allowed for today’s discussion. This partial list just demonstrates the diversity of American agriculture. Citrus canker (*Xanthomonas axonopodis* pv. *citri*) is found in Florida and there has been an extensive eradication program since its appearance in 1995. Tomato Yellow Leaf Curl Virus is highly virulent and spreading across the southern U.S. Plum pox virus is found in Pennsylvania, and also has an extensive eradication program underway. Wheat breeders have developed wheat rust resistant varieties but new races are emerging. Sudden oak death (*Phytophthora ramorum*) has been found in northern California since 1995 and is highly destructive to oak forests there. Finally, Rice Blast (*Magnaporthe grisea*) is found in the southern US and is easily spread by wind, weeks, and seeds.
Several plant pathogens can lead to trade complications if found within the U.S. Karnal bunt (*Tilletia indica*) is a fungus that affects wheat and areas in the U.S. that are affected are no longer permitted to export wheat or ship it out of their area. Maize streak virus is transmitted by leafhoppers and affects grasses, wheat and maize primarily in Africa. It was most recently introduced into Florida. Bacterial Wilt (*Ralstonia solanacearum*, Race 3, Biovar 2) causes disease in several agricultural crops such as potatoes, tomatoes, peppers and eggplant. This pathogen was detected in 2003 in some US greenhouses that received imported red geranium plants, but was subsequently eradicated. Cucurbit Yellow Stunt Disorder Virus is transmitted by a whitefly and was confirmed in the Lower Rio Grande Valley of Texas in 1999. This virus causes severe yellowing in cantaloupe, which is associated with significant yield losses, but the symptoms and impact on yield are less severe in watermelon. The virus has a host range restricted to the cucurbits. Pictured is maize streak virus on a maize plant. For more information on plant pathogens with trade issues, access the USDA-APHIS-PPQ website at http://www.aphis.usda.gov/ppq/ep/.

Karnal bunt is caused by the fungus *Tilletia indica* and affects wheat crops in Pakistan, India, Mexico, the U.S, and other countries. It spreads mainly by the planting of infected seeds. The organism survives and infects plants best in cool climates that have good rainfall and high humidity during the time of heading of wheat. While Karnal bunt does not drastically reduce crop yield, it does convey a fishy taste to the final wheat product making it undesirable. This pathogen also carries international trade restrictions, thus making it a great concern to the $3.6 billion dollar U.S. wheat export industry. Karnal bunt was first documented in the U.S. in 1996 in the wheat fields of Texas, California, and Arizona. In 2001, this disease had spread outside regulated areas and was discovered in Young County, TX. This pathogen can remain in the soil for up to 5 years and spores can be carried on various plant parts, farm equipment, tools, vehicles, and can be found on the surfaces of buildings.

The effectiveness of crop pathogens depends on many factors such as meteorological conditions, season, temperature, rain, sun, wind. These all play a role in how well a new agent will survive, take hold, and spread. The agent may be effective against a particular plant, but there may be limitations in the stage of growth of the plant and its susceptibility, as with Karnal bunt of wheat. In order for the agent to be considered for use, it must be available to the terrorist and relatively easy to grow. In applying the agent, there are many natural variables such as weather, time of year, terrain, susceptibility, hardiness of the agent, amount of agent applied, method of application, and whether or not the agent requires a vector, wind, or mechanical transmission for spread all affect the outcome.

The effectiveness of crop pathogens depends on many factors such as meteorological conditions, season, temperature, rain, sun, wind. These all play a role in how well a new agent will survive, take hold, and spread. The agent may be effective against a particular plant, but there may be limitations in the stage of growth of the plant and its susceptibility, as with Karnal bunt of wheat. In order for the agent to be considered for use, it must be available to the terrorist and relatively easy to grow. In applying the agent, there are many natural variables such as weather, time of year, terrain, susceptibility, hardiness of the agent, amount of agent applied, method of application, and whether or not the agent requires a vector, wind, or mechanical transmission for spread all affect the outcome.
Throughout this presentation, we hope you have learned that threats need to be taken very seriously, as in the Wisconsin incident. A framework needs to be established for proper response and coordination in large events. Expertise is needed to determine the extent of the attack, preventing disease spread and the losses that accompany it, preventing any public health implications, and in finding the perpetrator, which could be the most difficult.

On our farms, both livestock and grain, we need to continually enhance biosecurity. Biosecurity measures need to be tailored to each farm or production facility, while keeping the cost-benefit analysis of these recommendations in mind. Individual farm analysis of biosecurity measures do not readily take into consideration national or state concerns over foreign animal disease incursion or emerging diseases. Some universal precautionary measures will need to be adopted by all farms for the greater good of agriculture. The USDA, Animal and Plant Health Inspection Service is vital to the biosecurity of American farms as are industry groups such as those that represent the beef, dairy, pork, and poultry industries. The National Pork Board has done an excellent job in educating pork producers on biosecurity.

As we have seen, agroterrorism is a real threat that would impact nearly every citizen if severe enough. The economic consequences of an incident may seem insurmountable, but can be mitigated through planning and preparedness. Awareness of farmers, producers, law enforcement, HAZMAT teams, fire departments, veterinarians, local and state emergency management agencies, and even the community at-large and media will help in recognizing agriculture’s risks and implementing preventive measures. Many agencies and individuals are already working to ensure the safety of our agriculture through various monitoring efforts. It is important to remember that there is minimal direct human illness from any of the high consequence livestock pathogens. Continued diligence, training, and preparation will ensure that we are prepared in case such a terrible event should ever take place. The U.S. is the leader in providing food for the world, but in order to maintain this position we must be prepared and ever vigilant.
Sections of this presentation were taken from “Davis RG. Agroterrorism: Need for awareness. In: Scanes C, ed. Perspectives in world food and agriculture: 2003. Ames, IA: ISU Press. In press., 2003.” The USDA-APHIS website is also another good resource for more information on many of the agroterrorism topics covered in this presentation. The OIE website will give a broad overview of the high consequence livestock pathogens.

Acknowledgments
Development of this presentation was funded by a grant from the Centers for Disease Control and Prevention to the Center for Food Security and Public Health at Iowa State University.

Acknowledgments
Radford G. Davis, DVM, MPH
Danelle Bickett-Weddle, DVM